

Curriculum Vitae

Zoltán Toroczkai

Technical Staff member

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Birth Date: February 25 1968
Immigration: US permanent resident
Citizenship: Romania
LANGUAGES: English, Hungarian, Romanian

RESEARCH INTERESTS:

- Agent-based Systems Modeling: multiplayer games, game theory, collective intelligence and optimization
- Complex Networks: structural characterization and statistical physics of complex networks with applications to infrastructure networks and social network models, terrorist network modeling
- Massively parallel computation: computational and measurement scalability
- Statistical Physics and Non-equilibrium Statistical Mechanics: spin systems, exactly solvable models, random walks
- Nonlinear Dynamical Systems and Chaos: nonlinear time series analysis, thermodynamic formalism, chaos control and synchronization
- Biophysics: population dynamics, genetic sequence modeling, species coexistence
- Fluid Dynamics: chaotic advection, chemical/biological activity in chaotic flows
- Surface growth, interface dynamics: Molecular Beam Epitaxy, growth instabilities

EMPLOYMENT and EDUCATION HISTORY:

- Technical Staff Member, Complex Systems Group, LANL, 2002-present
- Director's Fellowship, Los Alamos National Laboratory, 2000-2002.
- Research Associate, University of Maryland at College Park, 98–2000.
- Graduate Research Assistant and Research Associate, Virginia Tech, 94–98.
- MHB research fellow, Eötvös University, Hungary, 1992-94.

EDUCATION:

- **Ph.D.** : May 9, 1997, Virginia Tech, in Physics. Thesis: “Analytic Results for Hopping Models with Excluded Volume Constraint”, advisor Royce K.P. Zia.
- **Diploma de Licensă (MSc.)**: June 1992, Babeş-Bolyai University, Romania, in Physics.

AWARDS AND HONORS:

- 1999 Special Merit Award for Outstanding Participation in the Materials Research Science and Engineering Center's Education Outreach Program, University of Maryland
- 1997 National Science Foundation and the Georgia Institute of Technology ICMP Travel Grant for the XIIth International Congress of Mathematical Physics, Brisbane, Australia
- 1996 C.H. Wan Scholarship for academic excellence in physics, Virginia Tech
- 1995 Bolyai College of Eötvös University, Supplementary Grant for Summer School and Workshop, Budapest, Hungary
- 1993 Niels Bohr Institute Supplementary Grant for Summer School, Humlabæk, Denmark
- 1992 Erdélyi Múzeum Egyesület and the Department of Education of Hungary Scholarship
- 1991 Soros Foundation Travel Award for ICPS Vienna, Austria
- 1989 Special Prize, "Traian Lalescu" National Problem Solving Competition in Physics, Romania

PROFESSIONAL ACTIVITIES:

- **Conference/Seminar organizer for:**
 - LANL-IMA workshop on *Agent based Modeling and Simulations*, November 3-6, 2003, Minnesota
 - CNLS 23rd Annual International Conference on *Networks: Structure, Dynamics, and Function*, May 12-16, 2003, Hotel La Fonda, Santa Fe
 - Agent-based Modelling and Simulations Seminar series, February - November 2001, LANL, Los Alamos
 - International Workshop on *Chemical and Biological Activity in Flows*, Max-Planck Institute for Complex Systems, August 26 - September 27, 2002, Dresden, GERMANY
 - CNLS/TDO LANL Workshop on *Anomalous Distributions, Nonlinear Dynamical Systems, and Nonextensivity*, November 04-08, 2002, LANL, Los Alamos
 - CNLS-LANL International Workshop on *Active Chaotic Flow*, May 2001, Los Alamos, USA;
 - SIAM-DS01 Minisymposium on *Active Chaos in Environmental Flows*, May 2001, Snowbird, Utah, USA;
 - Dynamics Days, Fifteenth Annual Informal Workshop, June, 1994, Budapest, HUNGARY (over 300 participants)
- **Referee for:** Physics Today, Journal of Fluid Mechanics, Physics of Fluids, Physical Review Letters, Physical Review, Physics Letters A, Surface Science, Chaos, and AIP Conference Proceedings, ANDM'97

- **Guest Editor for:** CHAOS, Special Focus Issue on Active Chaotic Flow, June 2002.
- **Editor for:** Lecture Notes in Physics, volume on *Complex Networks*, Springer-Verlag, scheduled for 2004.

Current Projects:

- **EpiSim.** The project goal is to work out vaccination and mitigation strategies for small-pox and similar epidemics for large-scale urban populations. The project requires the analysis of massive people contact-networks, in which I am heavily involved. The contact graph data are generated by a large-scale virtual city simulation instantiated by demographic land-use census data and people diaries. Project results are reported in Reference [49.] of the publications list. LANL collaborators: Stephen Eubank, Madhav Marathe, Anil Vulikanti, the EpiSim group.
- **TAP.** The Terrorist Anticipation Project, sponsored by DTRA, aims at creating an agent-based, dynamic model for social unrest, and anticipating the likelihood of a terrorist attack as a result of the dynamic interplay between the cooperation on the social network level among the agents, availability of resources, and exogenous pressure factors (such as economical embargo's and military actions). I participated in the design of the dynamic social network model and interaction rules. LANL collaborators: Ed. MacKerrow, Dennis Powell, Joe Holland, Brian Reardon, Merle Lefkoff.
- **TCP/IP network Protocol Analysis.** This project aims at constructing reduced complexity models for TCP/IP protocol behavior across large-scale networks and analyzing the nonlinear behavior of packet transmission, which recently has been shown to be responsible for packet transmission instabilities and jamming. I am working on adopting Karhunen-Loëve techniques to accomplish model reduction. LANL collaborators: Madhav Marathe and Gabriel Istrate.

Media appearances, interviews:

- Interviewed by Ian Austen of New York Times, interview published in New York Times, February 27, (2003): *With 6 Degrees of Separation, Computers Stay in Sync*, <http://www.nytimes.com/2003/02/27/technology/circuits/27next.html?ex=1047357089&ei=1&en=be1b5dd6ca6ef132>
- Interviewed by Mike Martin of Science Newsweek, interview published in Newsfactor, February 6, 2003: *Cascading Failures Could Crash the Global Internet*, <http://www.newsfactor.com/perl/story/20686.html>
- Nature Science Update Article published in Nature, 15 December, (2000): *Still waters run species out* by Phillip Ball, on the PNAS article [29.].

COMPLETE LIST OF PUBLICATIONS:

Peer reviewed and working papers

53. Z. Toroczkai, I.J. Benczik, T. Tél, D.R. Powell. Controlling Chaotic Games to their Nash Equilibria. working paper, (2003).
52. Z. Toroczkai. Gradient Networks. working paper, (2003).
51. Z. Toroczkai. Shell Theory of Complex Networks. working paper, (2003).
50. S. Eubank, H. Guclu, V.S.A. Kumar, M. Marathe, A. Srinivasan, Z. Toroczkai and N. Wang. Monitoring and Mitigating Small-Pox Epidemics: strategies drawn from a Census Data Instantiated Virtual City. preprint, to be submitted (2003).
49. T. Tél, T. Nishikawa, A.E. Motter, C. Grebogi, and Z. Toroczkai. Universality in active chaos. preprint, submitted to *Nature*; LA-UR-02-7579
48. M. Anghel, Z. Toroczkai, K.E. Bassler, G. Korniss. Competition in Social Networks: Emergence of a Scale-free Leadership Structure and Collective Efficiency. preprint, submitted to *Phys.Rev.Lett.* (2003). LA-UR-02-7580
47. I.J. Benczik, Z. Toroczkai and T. Tél. Advection of Finite-size Particles in Open Flows. *Phys.Rev.E* **67** 036303 (2003).
46. I. Scheuring, T. Czárán, P. Szabó, G. Károlyi, and Z. Toroczkai. Spatial models of prebiotic evolution: soup before pizza? *Origins of Life and Evolution of the Biosphere*, in press, (2003).
45. G. Korniss, M.A. Novotny, H. Guclu, Z. Toroczkai, P.A. Rikvold, Suppressing Roughness of Virtual Times in Parallel Discrete-Event Simulations. *SCIENCE*, **299**, 677 (2003); LA-UR-02-5811.
44. I.J. Benczik, Z. Toroczkai and T. Tél. *Phys.Rev.Lett.* **89**, 164501 (2002); cover-page article; LA-UR-02-2364
43. I. Scheuring, G. Károlyi, Z. Toroczkai, T. Tél, and Á. Péntek. Competing populations in flows with chaotic mixing. *Theor.Pop.Biol.* **63**(#2), 77 (2003); LA-UR-01-4666.
42. J.M. Finn, J.D. Goette, Z. Toroczkai, M. Anghel and B.P. Wood. Estimation of Entropies and Dimensions by Nonlinear Symbolic Time Series Analysis. *Chaos*, **13**(# 2), 444 (2003); LA-UR-02-3386.
41. S. Das Sarma, P.P. Chatraphorn, Z. Toroczkai. Universality class of discrete solid-on-solid limited mobility nonequilibrium growth models for kinetic surface roughening. *Phys. Rev. E*, **65**, 0366144 (2002).
40. Z. Toroczkai, T. Tél. Introduction: Active Chaotic Flow. *Chaos*, **12**(#2), 372 (2002)

39. Z. Toroczkai. Topological classification of the Horton-Strahler index on binary trees, *Phys.Rev.E*, **65** 016130 (2002); LA-UR-01-5224.
38. G. Korniss, M.A. Novotny, P.A. Rikvold, H. Guclu and, Z. Toroczkai. Going Through Rough Times: from Non-equilibrium Surface Growth to Algorithmic Scalability. Materials Research Society Symposium Proceedings, Statistical Mechanical Modelling in Materials Research, Series **700**, 297 (2002); LA-UR-01-6631.
37. G. Santoboni, T. Nishikawa, Z. Toroczkai and C. Grebogi. Autocatalytic reactions of phase distributed active particles. *Chaos*, **12**(#2), 408 (2002); LA-UR-01-6099
36. M. Chertkov, I. Gabitov, P. Lushnikov, J. Moeser, and Z. Toroczkai. Pinning method of pulse confinement in optical fiber with random dispersion. *J.Opt.Soc.Am. B*, **19**, 2538 (2002); LA-UR-01-5307.
35. T. Nishikawa, Z. Toroczkai, C. Grebogi and T. Tél. Finite size effects on active chaotic advection, *Phys.Rev.E*, **65** 026216 (2002); LA-UR-00-0613.
34. P. Punyindu, Z. Toroczkai, S. Das Sarma. Epitaxial Mounding in Limited-Mobility Models of Surface Growth, *Phys.Rev.B*, **64**, 205407 (2001); LA-UR-00-0614.
33. Z. Toroczkai, G. Károlyi, Á. Péntek, T. Tél, and I. Scheuring. Autocatalytic Reactions in Systems with Hyperbolic Mixing: Exact Results for the Active Baker Map, *J.Phys.A: Math.Gen.* **34**, 5215 (2001); LA-UR-00-5814.
32. Z. Toroczkai, G. Korniss. Comment on “Extremal-Point densities of interface fluctuations in a quenched random medium”. *Phys.Rev.E*, **64** 048101 (2001); LA-UR-01-1332.
31. T. Nishikawa, Z. Toroczkai, and C. Grebogi. Advective coalescence in chaotic flows *Phys.Rev.Lett* **87** 038301 (2001); LA-UR-00-4319.
30. I. Miklós and Z. Toroczkai, An improved model for statistical alignment. *Lecture Notes In Computer Science* **2149**, pp. 1-10, (2001). LA-UR-01-3270. O.Gascuel, B.M. Moret (Eds.):**Algorithms in Bioinformatics** First International Workshop, WABI 2001, Aarhus, Denmark, Aug. 28-31, 2001.
29. G. Károlyi, Á. Péntek, I. Sheuring, T. Tél, and Z. Toroczkai. Chaotic flow: the physics of species coexistence, *Proc. Natl. Acad. Sci. USA*, **97** 13661 (2000) ; LA-UR-00-3602.
28. I. Sheuring, G. Károlyi, Á. Péntek, T. Tél, Z. Toroczkai. A model for resolving the plankton paradox: coexistence in open flows, *Freshwater Biology*, **45**, 123 (2000); LA-UR-00-4107.
27. Z. Toroczkai, G. Korniss, S. Das Sarma, and R. K. P. Zia. Extremal-Point densities of interface fluctuations, *Phys.Rev.E*, **62**, 276 (2000) .

26. G. Korniss, Z. Toroczkai, M.A. Novotny, and P.A. Rikvold. From massively parallel algorithms and fluctuating time horizons to non-equilibrium surface growth, *Phys.Rev.Lett.* **84** 1351 (2000).
25. S. Das Sarma, P. Punyindu, and Z.Toroczkai. Nonuniversal mound formation in nonequilibrium surface growth, *Surf. Sci. Letters*, **457**, L369, (2000).
24. T. Tél, G. Károlyi, Á. Péntek, I. Sheuring, Z. Toroczkai, C. Grebogi and J. Kadtke. Chaotic advection, diffusion, and reactions in open flows, *Chaos*, **10**, 89 (2000).
23. Z. Toroczkai, and E.D. Williams. Nanoscale fluctuations at solid surfaces, *Physics Today*, **52**, 24 (1999)
22. G. Károlyi, Á. Péntek, I. Sheuring, T. Tél, Z. Toroczkai, C. Grebogi, and J. Kadtke. Fractality, chaos, and reactions in imperfectly mixed open hydrodynamical flows, *Physica A* **274**, 120 (1999); Also to be published in a standalone book by Elsevier, *Applications of Statistical Physics*.
21. Z. Toroczkai, T. J. Newman and S. Das Sarma. Sign-time distributions for interface growth *Phys. Rev. E* **60**, R1115 (1999)
20. G. Károlyi, Á. Péntek, Z. Toroczkai, T. Tél, and C. Grebogi. Chemical or biological activity in open chaotic flows, *Phys. Rev. E* **59**, 5468 (1999)
19. T. J. Newman and Z. Toroczkai. Diffusive persistence and the "sign-time" distribution *Phys. Rev. E* **58**, R2685 (1998)
18. R.K.P. Zia and Z. Toroczkai. Random walk with a hop-over site: a novel approach to tagged diffusion and its applications, *J. Phys. A: Math.Gen.* **31**, 9667 (1998)
17. Z. Toroczkai, G. Károlyi, T. Tél, Á. Péntek, and C.Grebogi. Advection of active particles in open chaotic flows *Phys. Rev. Lett.* **80**, 500 (1998)
16. Z. Toroczkai, G. Korniss, B. Schmittmann, and R.K.P. Zia. Brownian-vacancy mediated disordering dynamics, *Europhys. Lett.* **40**, 281 (1997)
15. Z. Toroczkai. The Brownian vacancy driven walk, *Int. J. Mod. Phys. B* **11**, 3343 (1997)
14. Z. Toroczkai, and R.K.P. Zia. Periodic one-dimensional hopping model with one mobile directional impurity, *J. Stat. Phys.* **87**, 545 (1997)
13. Z. Toroczkai, G. Károlyi, Á. Péntek, T. Tél, C. Grebogi, and J.A. Yorke. Wada dye boundaries in open hydrodynamical flows, *Physica A***239**, 235 (1997)
12. Á. Péntek, T. Tél, and Z. Toroczkai. Transient chaotic mixing in open hydrodynamical flows, *Int. J. Bif. Chaos.* **6**, 2619 (1996)
11. Á. Péntek, J.B. Kadtke, and Z. Toroczkai. Stabilizing chaotic vortex trajectories: an example of high dimensional control, *Phys. Lett.* **A224**, 85 (1996)

10. Z. Toroczkai, and R.K.P. Zia. A model for electrophoresis of polymers with impurities: exact distribution for a steady state, *Phys. Lett.* **A217**, 97 (1996)
9. B. Sas, and Z. Toroczkai. Continuous extension of the geometric control method, *J. Phys. A: Math. Gen.* **29**, 3545 (1996)
8. Á. Péntek, Z. Toroczkai, T. Tél, C. Grebogi, and J.A. Yorke Fractal boundaries in open hydrodynamical flows: signatures of chaotic saddles, *Phys. Rev. E* **51**, 4076 (1995)
7. Á. Péntek, T. Tél, and Z. Toroczkai. Chaotic advection in the velocity field of leapfrogging vortex pairs, *J. Phys. A: Math. Gen.* **28**, 2191 (1995)
6. Á. Péntek, T. Tél, and Z. Toroczkai. Fractal tracer patterns in open hydrodynamical flows: the case of leapfrogging vortex pairs, *Fractals* **3**, 33 (1995)
5. Z. Toroczkai. Geometric method for stabilizing unstable periodic orbits, *Phys. Lett.* **A190**, 71 (1994)
4. Á. Péntek, Z. Toroczkai, D.H. Mayer, and T. Tél. A generalized Kac model as a dynamical system, *Z. Naturforsch.* **49a**, 1212 (1994)
3. Z. Toroczkai and Á. Péntek. Detecting phase transitions in intermittent systems by using the thermodynamical formalism, *Z. Naturforsch.* **49a**, 1235 (1994)
2. Á. Péntek, Z. Toroczkai, D.H. Mayer, and T. Tél. Kac Model from a dynamical system's point of view, *Phys. Rev. E* **49**, 2026 (1994)
1. Z. Toroczkai and Á. Péntek. Classification criterion for dynamical systems in intermittent chaos, *Phys. Rev. E* **48**, 136 (1993)

Book chapters:

3. Z. Toroczkai, G. Korniss, M.A. Novotny and H. Guclu. Virtual Time-Horizon Control via Communication Network Design. In **Computational Complexity and Statistical Physics**, eds. A. Percus and G. Istrate, in press (Oxford University Press, 2003).
2. Z. Toroczkai, M. Anghel, G. Korniss, K.E. Bassler. Effects of Inter-agent Communications on the Collective. In: **Collectives and the Design of Complex Systems**, eds.: K. Tumer and D.H. Wolpert, (Springer, 2004, in press) LA-UR-03-0611.
1. G. Károlyi, Á. Péntek, T. Tél, and Z. Toroczkai. Chaotic tracer dynamics in open hydrodynamical flows, in **Nonlinear Dynamics, Chaotic and Complex Systems**, eds. E. Infeld, R. Zelazny, and A. Galkowski, (Cambridge University Press, Cambridge, 1997, pp. 24)

Proceedings:

3. G. Korniss, M.A. Novotny, Z. Toroczkai, and P.A. Rikvold. Non-equilibrium Surface Growth and Scalability of Parallel Algorithms for Large Asynchronous Systems, **Computer Simulation Studies in Condensed Matter Physics XIII**, eds. D.P. Landau, S.P. Lewis, and H.-B. Schuttler, **86** 183 (2001)
2. G. Károlyi, Á. Péntek, T. Tél, and Z. Toroczkai. Hydrodynamically driven chemical or biological activity in open flows, *Proceedings of the: British-Finnish-Hungarian Workshop on Refined Flow and Transport Modeling in Shallow Water Environment*, Budapest, Hungary, April, (1999).
1. Á. Péntek, J.B. Kadtk, and Z. Toroczkai. Controlling symmetric vortex configurations, *Proceedings of ANDM'97, AIP Conference*, No. 411, pp. 109 (American Institute of Physics Publishing, 1997)

Other publications:

4. Á. Péntek, and Z. Toroczkai, Éltető káosz a planktonok világában, (in Hungarian), *Korunk, in press*
3. Z. Toroczkai. Analytic results for hopping models with excluded volume constraint, *Ph.D. Dissertation* Virginia Tech, 1997
2. Z. Toroczkai. Haosul intermittent. Tranzitii de fază (in romanian), *Diploma Thesis* Babeş-Bolyai University, Cluj, Romania, 1992.
1. Z. Toroczkai. Asymptotic behavior of discrete dynamical systems in chaos, *Studia Universitatis Babes-Bolyai, PHYSICA* 1, 73 (1990)

PRESENTATIONS AT CONFERENCES AND INVITED TALKS:

- APS March Meeting, 2003, Austin, TX (lecture)
- Eötvös University Physics Department Colloquium, Budapest, Hungary, December 2002
- NASA workshop on Collectives and the Design of Complex Systems, NASA, Ames, August 2002 (invited lecture)
- UCLA conference on Agent-based modeling in the social sciences, Lake Arrowhead, CA, May, 2002 (invited lecture)
- EGS XXVII assembly meeting, Nice, France, April 2002 (invited lecture)
- Northwestern University, Chemical Engineering Colloquium, February 2002
- Santa Fe Institute Workshop on Mathematical Foundations of Distributed Intelligence, Santa Fe, January 2002 (invited lecture)
- CNLS Statistical Physics Working Seminar Series, Fall, 2001 (3 lectures)
- Workshop on Computational complexity and Stat. Physics, Santa Fe, Sept. 2001 (invited lecture)
- P/T Colloquium, May 10, LANL, 2001 (invited colloquium)
- SIAM-DS01 Dynamical Systems meeting, Snowbird, Utah, 2001 (invited lecture)
- Eötvös University, Budapest, Hungary, 2000 (invited colloquium)
- Renssellaer Polytechnic Institute, Troy, NY, 2000 (invited colloquium)
- Duke University, CNLS-CNCS Workshop Durham, NC, 2000 (invited lecture)
- University of Virginia, Charlottesville, VA, 1999 (invited lecture)
- APS Centennial Meeting, Atlanta, GA, 1999 (lecture)
- University of Maryland at College Park, 1998 (2 lectures)
- Center for Nonlinear Studies, Los Alamos National Laboratory, 1998 (invited lecture)
- Rutgers University, New Jersey, 1995, 1996, 1998 (short talks)
- XIIth International Congress of Mathematical Physics, Brisbane, Australia, 1997 (invited lecture)
- Statistical Physics at the 45th Parallel, University of Rochester, NY, 1996 (lecture)
- CPIP'96, London, Ontario, Canada, 1996 (lecture)
- Virginia Tech, Blacksburg, VA, 1995 (2 lectures)
- The Statistical Description of Non-equilibrium Steady States, Eötvös University, Budapest, Hungary, 1995 (lecture)
- Dynamics Days, Fifteenth Annual Informal Workshop, Budapest, Hungary, 1994 (poster)
- Dynamics Days, Fourteenth Annual Informal Workshop, Poznañ, Polland, 1993 (2 posters)
- Workshop on Complex Systems: Turbulence, Chaos, Neural Networks, Humlabæk, Denmark, 1993 (lecture)